# Human Factors Assessments
# in
# Investment Analysis:
## Definition and Process Summary for Cost, Risk, and Benefit

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# Human Factors Assessments in Investment Analysis:
## Definition and Process Summary for Cost, Risk, and Benefit

**Purpose:**  This document provides a brief description of a "Human Factors Assessment" especially those conducted during the Investment Analysis process.

**Definition:** The Human Factors Assessment is a process that is integrated with other processes and provides essential components to the products of the Investment Analysis (IA).  Three of these human factors components are: a) the human-system performance contribution to program benefits, b) an assessment of the human-system performance risks, and c) the estimated costs associated with mitigating human factors risks and with conducting the engineering program support.  The human factors components related to benefits, risks, and costs are integrated with other program components in the IA products and documentation.

**Background:**  During the conduct of the FAA Acquisition Management System (AMS) Investment Analysis phase, human factors research and engineering practitioners conduct various activities to provide critical information to the program and program documentation. The purpose of conducting human factors research and engineering activities (as outlined in Appendix E of the FAA Human Factors Job Aid, dated March 1999, at  during the IA process is to ensure that✚
  o   Human-system performance capabilities and limitations are properly reflected in the system requirements (e.g., IRD/FRD)
  o   Human-system performance characteristics and their associated cost, benefits, and risks assist in deciding among alternatives (e.g., IAP, IAR)
  o   Human-system performance risks and their mitigation are appropriately addressed in program baselines and plans (e.g. APB, IPP)

**Process Description:** As the sponsor of investment analyses, ASD-400 has identified a process for the inclusion of the human factors contribution to IA products.  These contributions may support the "comparative" evaluation of solution alternatives being considered or support the "detailed" definition of one or more selected alternatives. In coordination with AAR-100, Investment Analysis Teams (including benefits, cost, and risk assessment sub-teams) identify human factors practitioners to support the IA process.  In conjunction with producing the Human Factors Assessment for Investment Analysis, these human factors practitioners also support IA team activities including:
  o   Investment Analysis Plan
  o   Requirements Definition Activities
  o   Market Survey
  o   Alternative Solution Identification and Analysis
  o   Affordability Assessment and Trade Studies
  o   Acquisition Program Baseline Development
  o   Investment Analysis report, briefing, and recommendations

# Human Factors Assessments in the Investment Analysis

**HF BENEFITS ANALYSIS (New Capabilities)**

Human-in-the-Loop Performance Limitations

Human-in-the-Loop Performance Enhancements

**IMPACT OF HF BENEFITS ON COST**

Cost Avoidance (-)

Cost of Improved Effectiveness (+)

**HF RISK ANALYSIS**

HF Risks
(1) . . .
(2) . . .
(*n*) . . .

HF Risk Ratings
(1) . . .
(2) . . .
(*n*) . . .

HF Risk Mitigation Strategies
(1) . . .
(2) . . .
(*n*) . . .

**INTEGRATION INTO IA PRODUCTS**

Risk Analysis

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Cost Benefit Analysis

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Acquisition Program Baseline

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IA Report

**HF COST ANALYSIS**

HF Risk Mitigation Costs **+** HF Benefits Cost **=** HF Cost → Standard WBS (Level 2)
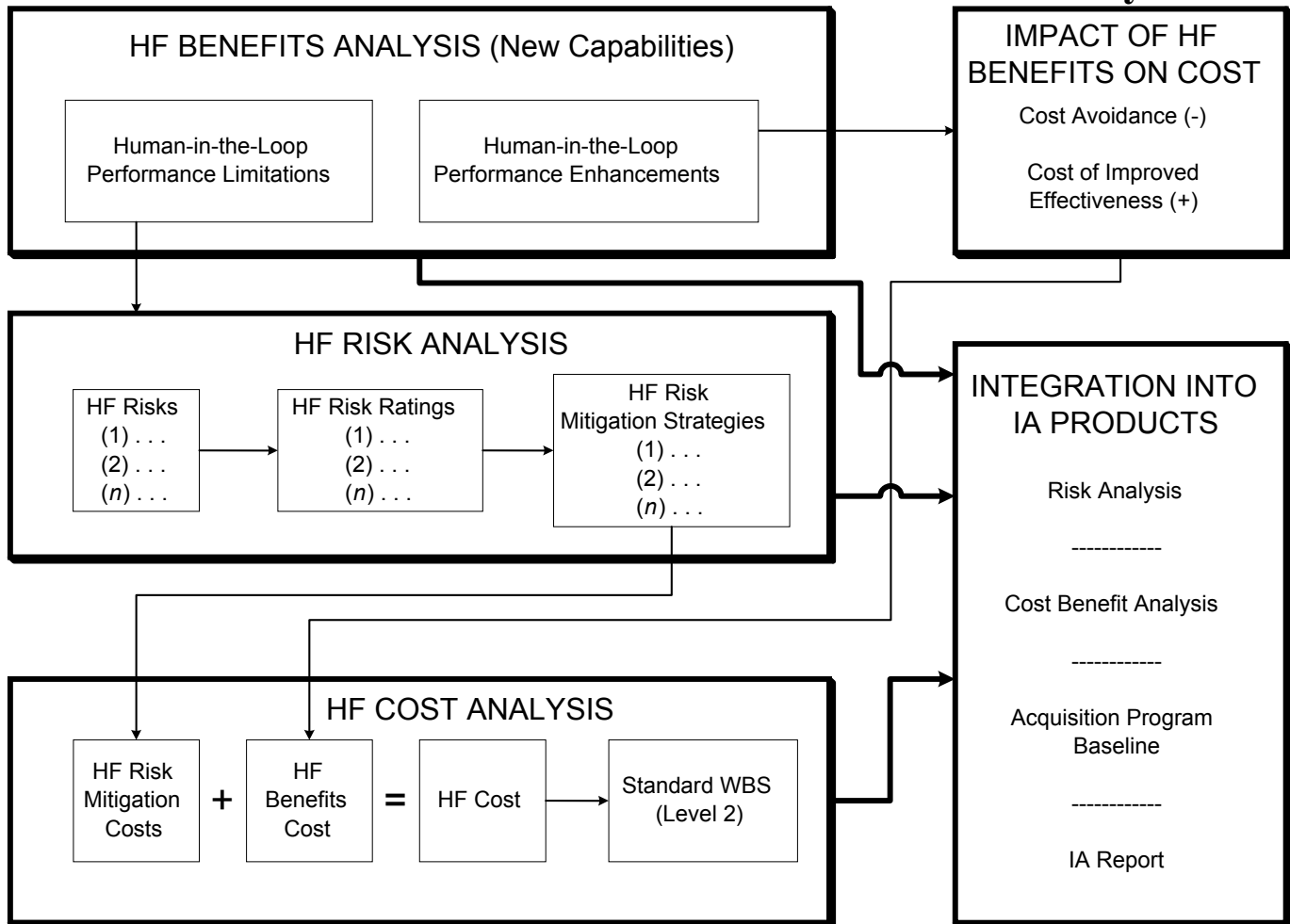
FIGURE 1:  The relationship of Human Factors Assessment key products to the major products of the Investment Analysis phase

In addition to other support activities, human factors practitioners provide input to IA products related to benefits, risks, and costs as depicted in Figure 1 and outlined below:

o   **Benefits:**  Efforts related to identifying system/program benefits provided in quantitative and qualitative terms must be congruous with human-in-the-loop performance limitations and performance enhancements.  There are various ways by which to conduct the benefits analysis for human-in-the-loop performance impacts, including the methodology described in "Framework for Evaluation of Human-System Issues with ASDE-X and Related Surface Safety Systems" prepared by Raja Parasuraman (Catholic University of America), John Hansman (Massachusetts Institute of Technology), Steven Bussolari (Massachusetts Institute of Technology) dated January 12, 2002, at the FAA Human Factors website .  The activities necessary to identify human-in-the-loop performance (potential) limitations provide the basis for conducting a human factors risk analysis (see "Risks" below).  Human-in-the-loop performance enhancements are likely to reflect both cost avoidance opportunities (e.g., lower staffing, lower training time, lower costs) and operational improvements (e.g., increased safety, more effective procedures, increased performance and productivity).  [Note: These

performance enhancements may not come free of costs which must also be captured in the IA cost analysis.]

o **Risks:** Efforts related to system/program risks must include the human factors and human-system performance risks. There are various ways to identify and categorize the human factors risks including an approach that rates (high, medium, low, or not applicable) the human factors risk areas listed in Attachment 1. [Note: A rating for one human factors risk area is generally considered sufficient to rate human factors at that level of risk. Also, because the accumulation of several low risks may result in a higher probability of an adverse event, the cumulative impact of low risk areas should be assessed. For the purposes of establishing a consistent approach to accumulated risks, generally six or more risks in a lower level may be considered sufficient to raise the risk rating to the next higher level.] For each of the risk areas, the human factors practitioner provides a risk assessment, a mitigation strategy, and an estimated cost for resolving or mitigating the identified risk (see "Costs" below). (These risk areas may also serve as an indication of the level of the complexity of the human-system interface that impacts the cost of the human factors effort.) The mitigation strategies should be defined in enough detail to outline the essential actions or activities that need to be conducted during the design and development phase. These mitigation strategies and activities are later incorporated into the program acquisition strategy paper (ASP) and the integrated program plan (IPP).

o **Costs:** Efforts related to identifying system/program costs must include the estimated costs for mitigating the human factors risks and the costs for providing the necessary human-system performance enhancements. There are various ways to estimate human factors costs including those addressed in "Human Factors Program Cost Estimation - Potential Approaches," prepared by Dr, Parimal Kopardekar, March 23, 2002, at the FAA Human Factors website . An abbreviated method for estimating the human factors costs may be employed such as that described in Attachment 2. The estimated human factors cost provides an input to the total program cost estimates. Costs attributable to the human factors effort may include those sources listed at Attachment 3. In order to be integrated into the total program costs and the acquisition program baseline (APB), the human factors costs are distributed into the categories of the appropriate acquisition phase or work breakdown structure (see Attachment 4).

**Summary:** The steps involved in the Human Factors Assessment (HFA) for Investment Analysis are summarized in Attachment 5. The HFA provides essential input to IA products. These inputs may be in the form of "a comparative HFA" by providing relative evaluations for the different alternatives being considered or a "detailed HFA" for one or more selected alternatives. In either case, the HFAs consist of activities that:
o Integrate human performance considerations into IA products and processes
o Include but are not limited to benefits, risk, and cost assessments
o Provide benefit, risk, and cost information that are combined with other IA and program products

**Point of Contact:** For additional information, contact AAR-100 (Glen Hewitt, 202-267-7163, or Chuck Overbey, 202-267-7938).

# Attachment 1
# Human-System Performance Risks

**Overview:** Human factors risk analyses should provide information on what is known and unknown about the human-system performance in meeting minimum or desired system performance requirements. Human factors considerations that are relevant to meeting system performance and functional requirements include:

1) human performance (e.g., human capabilities and limitations, workload, function allocation, hardware and software design, decision aids, environmental constraints, and team versus individual performance)
2) training (e.g., length of training, training effectiveness, retraining, training devices and facilities, and embedded training)
3) staffing (e.g., staffing levels, team composition, and organizational structure)
4) personnel selection (e.g., minimum skill levels, special skills, anthropometrics, demographics, and experience levels)
5) safety and health aspects (e.g., hazardous materials or conditions, system or equipment design, operational or procedural constraints, biomedical influences, protective equipment, and required warnings and alarms).

**Risk Areas:** The risk analyses and products provide, for each alternative, the full range of human factors and human-system interface requirements (e.g., cognitive, organizational, physical, functional, environmental) necessary to achieve an acceptable level of performance for operating, maintaining, and supporting the system. In these risk analyses, Table 1.1 provides a checklist to assist in the identification of risks. Table 1.2 provides criteria for estimating the probability of human factors risk and Table 1.3 provides criteria for estimating the severity of human factors risk. Risk areas that may need to be assessed include:

1. **Allocation of Function:** System design reflecting assignment of those roles/functions/tasks for which the human or equipment performs better while maintaining the human's awareness of the operational situation.
2. **Anthropometrics and Biomechanics:** System design accommodation of the physical attributes of the user population (e.g., from the 1st through 99th percentile levels) including access to and use of system components.
3. **CHI:** Employing standardized and effective user dialogues, interfaces, and procedures across system functions.
4. **Communications and Teamwork:** System design considerations to enhance required user communications and teamwork.
5. **Displays and Controls:** Design and arrangement of displays and controls to be consistent with the operator's and maintainer's tasks and actions.
6. **Documentation:** Preparation of user documentation and technical manuals in a suitable format of information presentation, at the appropriate reading level, and with the required degree of technical sophistication and clarity.
7. **Environment:** Accommodation of environmental factors (including extremes) to which the system will be subjected and the effects on human-system performance.
8. **Functional Design:** Use of a human-centered design process to achieve usability objectives and compatibility with operation and maintenance concepts.
9. **Human Error:** Examination of design and contextual conditions (including supervisory and organizational influences) as causal factors contributing to human error, and consideration of objectives for error tolerance and error resistance.
10. **Information Presentation:** Enhancement of operator and maintainer performance through the use of effective and consistent labels, symbols, colors, terms, acronyms, abbreviations, formats, and data fields.
11. **Information Requirements:** Availability and usability of information needed by the operator and maintainer for a specific task when it is needed.
12. **I/O Devices:** Design and use of input and output devices for performing the task quickly and accurately, especially critical tasks.

13. **KSAs -** Measurement of the knowledge, skills, and abilities required to perform job-related tasks, and determination of appropriate selection requirements for users.
14. **Operational Suitability:** The interoperability and consistency of the design with other system elements or other support systems.
15. **Procedures:** Design of operation and maintenance procedures for simplicity, consistency, and ease of use.
16. **Safety and Health:** Prevention/reduction of operator and maintainer exposure to personnel and system safety and health hazards.
17. **Situational Awareness:** The ability to perceive and understand elements of the current situation, and project them to future operational situations.
18. **Special Skills and Tools:** Minimizing the need for special or unique operator or maintainer skills, abilities, tools, or characteristics.
19. **Staffing:** Accommodation of constraints and efficiencies for staffing levels and organizational structures.
20. **Training:** Consideration of the acquisition and decay of operator and maintainer skills on the system design and capability to train users easily, and design of the training regimen to result in effective training.
21. **Visual/Auditory Alerts:** Design of visual and auditory alerts (including error messages) to invoke the necessary operator and maintainer response.
22. **Workload:** Requirements for operator and maintainer physical, cognitive, and decision-making tasks, including objective and subjective performance measures.
23. **Work Space:** Design, configuration, and adequacy of work space for personnel and their tools and equipment, and sufficient space for the movements and actions they perform during operational and maintenance tasks under normal, adverse, and emergency conditions.

**Table 1.1 Human Factors Risk Checklist**

| Human Factors |
| --- |
| **Human-in-the-loop Effectiveness**<br>• Inadequate definition of human-in-the-loop operational objectives<br>• Inadequate specification of human-in-the-loop benefits<br>• Inadequate analysis of human-in-the-loop system capability to deliver expected benefits or enhancement<br>• Human error mechanisms not fully identified<br>• Time required to perform tasks is unknown<br>• Automation does not provide the necessary functionality to support effective decision-making/problem-solving<br><br> **Human-in-the-loop Suitability**<br>• Lack of consistency, compatibility, or congruity with operational environment or legacy systems.<br>• Human-system design/interface induces new/additional human error potential<br>• Inadequate incorporation of functional requirements to support user-system performance goals<br><br>**User Acceptability**<br>• New tasks impose excessive attentional, memory, or workload demands<br>• Requires new teaming and communication links<br>• Operations interface is unacceptable to user<br>• Maintenance interface is unacceptable to user |

## Table 1.2: Estimating the Probability of an Adverse Event Related to Human Factors

| High Probability of an Adverse Event | Medium Probability of an Adverse Event | Low Probability of an Adverse Event |
|---|---|---|
| If one or more of the following conditions are present:<br>1) System requirements or designs lack human-system performance objectives or are derived without comprehensive human-in-the-loop performance research, studies, or analyses.<br>2) Human-in-the-loop performance goals are unstated or not achievable within the proposed operational and maintenance concepts or using the proposed design approach.<br>3) Human interface issues and risk mitigation strategies are not adequately supported by research, funding, technical expertise, or other resources.<br>4) Proposed automation lacks analyses to ensure full functionality or information to support user tasks.<br>5) User tasks and skills are not well defined or do not conform to current skill levels.<br>6) Human-system task performance times are unknown or not quantified.<br>7) Potential for human error has not been quantitatively analyzed or the impact on human-in-the-loop system capabilities is unknown or changing.<br>8) Physical or cognitive human-system integration design elements are, individually or in the aggregate, unknown or sufficiently deficient to detract from efficient or effective task performance.<br>9) Requirements for integration of the system or its components into the user work environment are undetermined or changing.<br>10) User groups do not contribute to requirements development, design, or analysis. | If one or more of the following conditions are present:<br>1) System requirements or designs include incomplete human-system performance objectives or are derived with limited human-in-the-loop performance research, studies, or analyses.<br>2) Human-in-the-loop performance goals are partially stated or partially achievable within the proposed operational and maintenance concepts or using the proposed design approach.<br>3) Human interface issues and risk mitigation strategies are partially supported by research, funding, technical expertise, or other resources.<br>4) Analyses show proposed automation supports partial functionality and information needed to support user tasks.<br>5) User tasks and skills are defined but changing user roles require reevaluation of skills and training.<br>6) Human-system task performance times are partially known or partially quantified.<br>7) Potential for human error has been partially analyzed or impact on human-in-the-loop system capabilities is partially known.<br>8) Physical or cognitive human-system integration design elements are, individually or taken together, partially known.<br>9) Some elements of the integration of the system or its components into the user work environment are new or changing.<br>10) User groups partially contribute to requirements development, analysis, and design. | If all of the following conditions are present:<br>1) System requirements and designs include human-system performance objectives derived from comprehensive human-in-the-loop performance research, studies, and analyses.<br>2) Analysis indicates that human-in-the-loop performance goals are achievable within the proposed operational and maintenance concepts and using the proposed design approach.<br>3) Human interface issues and risk mitigation strategies are adequately supported by research, funding, technical expertise, and other resources needed to complete the design within program constraints.<br>4) Automation provides full functionality to support user decision-making.<br>5) User tasks and skills are well defined or remain essentially unchanged.<br>6) Human-system task performance times are known and acceptable.<br>7) Potential for human error has been quantitatively analyzed and impact on human-in-the-loop system capabilities is known.<br>8) Physical or cognitive human-system integration design elements are individually and taken together sufficiently mature to assure efficient or effective task performance.<br>9) Integration of the system or its components into the user work environment is fully compatible with the larger system and operations.<br>10) User group input is an integral part of requirements development, design, and analysis. |

## Table 1.3: Estimating the Severity of an Adverse Event Relating to Human Factors

| Substantial Severity of Impact | Moderate Severity of Impact | Minor Severity of Impact |
|---|---|---|

| | | |
|---|---|---|
| If one or more of the following conditions are present:<br>1) Size of the workforce affected by system changes is large and staffing levels and system performance goals are not supported by workload analyses.<br>2) Analyses indicate personnel skill and ability requirements are changing or unmet by current workforce.<br>3) Early training analyses are lacking or fail to influence selection of design alternatives for critical tasks such as problem solving and decision-making.<br>4) Physical and cognitive human-system integration design elements and integration of the system and its components into the user work environment have not been fully analyzed or do not comply with human factors engineering best practices.<br>5) System changes affect safety critical components and analyses have not yet proven system safety and workforce health are assured. | If one or more of the following conditions are present:<br>1) Size of the workforce affected by system changes is small and staffing levels and system performance goals are partially supported by workload analyses or by current staffing.<br>2) Analyses indicate personnel skill and ability requirements are partially met by current workforce.<br>3) Early training analyses partially identify factors affecting design alternatives for critical tasks.<br>4) Physical and cognitive human-system integration design elements and integration of the system and its components into the user work environment have been partially analyzed or partially comply with human factors engineering best practices.<br>5) System changes affect minor safety components or analyses show limited impact on system safety and workforce health. | If all of the following conditions are present:<br>1) Workload analyses assure that staffing levels support system performance goals.<br>2) Analyses indicate personnel skill and ability requirements are met by current workforce.<br>3) Early training analyses influenced alternative analysis and design to ensure ease in performing all critical tasks.<br>4) A human-centered design approach has been used to design the physical and cognitive human-system integration elements and the integration of the system and its components into the user work environment.<br>5) System changes affect no safety critical components and analyses have proven system safety and workforce health are assured. |

# Attachment 2
## Abbreviated Human Factors Cost Estimation Method

**General:** The cost of conducting human factors engineering support has been estimated to be between 0.5% and 6% of the program's developmental costs (depending upon many factors). Cost estimating methods (such as those identified in the concept paper "Human Factors Program Cost Estimation - Potential Approaches," prepared by Dr, Parimal Kopardekar, March 23, 2002, at the FAA Human Factors website focus on microscopic elements that affect human factors costs. The concept paper also enumerates some overarching macroscopic cost drivers. At the early stages of a program, macroscopic factors that may be used to estimate the human factors costs as a percentage of the program's developmental cost include:

1. *Definition of and Agreement on System Requirements* – The specificity and clarity of the human-system interface requirements, operational and maintenance concepts, concepts of use, expected task performance levels, and procedural guidelines determine the amount of uncertainty and risk in meeting system performance objectives and is a key factor affecting cost.
2. *The complexity of the human-system integration* – The complexity of the integration between the operator/maintainer and the system (including the human-system interface such as that reflected in the display design) increases the developmental and evaluations costs.
3. *Organizational culture and nature of relationships among management, user, and provider unions, industry, and other stakeholders (e.g., interests converge or negotiations are necessary)* -- The climate of an organization plays a role in determining how easily the new changes will be implemented. Some changes are easier to implement than others due to their perceived or actual acceptability. The changes that face resistance become costly since part of the cost goes towards ensuring that the resistance is managed. Often, a concept or technology offers differing benefits (or losses) to different stakeholders even though, on the average, they are beneficial to the NAS. Under such circumstances, time and cost need to be devoted to gain mutual consensus. Such processes increase the cost.
4. *Pace of program (e.g., aggressive, normal, slow)* -- As the program schedule becomes more aggressive, more resources are needed, and the cost increases in a shorter period.
5. *Safety and security considerations (e.g., higher security, or normal security)* -- As the safety and security requirements for equipment, technology, procedures, or decision support tools increase, more developmental activities and evaluations need to be conducted to assure the safety standards are met. This leads to higher cost.
6. *Collaboration with international, external, or domestic organizations for standardization and other reasons* -- Early collaboration with international and domestic partners increases the likelihood of ensuring that all requirements are taken into consideration. However, increased collaboration increases the cost and/or schedule of a program due to costs associated with increased deliberation and consensus on meeting broader requirements.

**Cost Estimates:** Derived from a survey of human factors professionals, Table 1 (below) provides attributes affecting program human factors costs, their relative weighting, attribute descriptors and values to be used as additive elements of the total program human factors development costs. Especially early in the acquisition, these may be used (and modified as appropriate) to estimate the human factors program cost. For example, if a program entails "normal" or "moderate" levels of all cost factors, the total human factors cost may be estimated at approximately 3% (from .75+.6+.6+.45+.3+.3) of the program developmental costs. Or, if the

program entails "normal" or "moderate" levels of all cost factors except a "very high" human-system integration/complexity," the total human factors costs may be estimated at approximately 4.2% (from .75+1.2+.6+.45+.3+.3) of the program developmental costs.

**Risk-Based Cost Estimates:** A "risk" or "confidence" level should be associated with the estimated human factors cost. Notionally, the cost should be estimated at the 80 or 90% confidence level to assure limited risk to the program. This risk-based cost estimate may be derived from the "most likely" or "best" estimate of the human factors costs, or it may be directly estimated by identifying the set of activities (and their costs) required to address 80 or 90% of the risk (or by reducing the "unmitigated" risks to 20 or 10%). Depending upon the type of acquisition, the distribution of human factors cost risk may be best estimated by a lognormal distribution. In the absence of additional risk-based cost information and for the purpose of relating estimated cost and risk level, the following relationship is provided:

C
O
S
T

P
R
O
B
A
B
I
L
I
T
Y

Most Likely
(30%)

Low
(10%)

High
(90%)
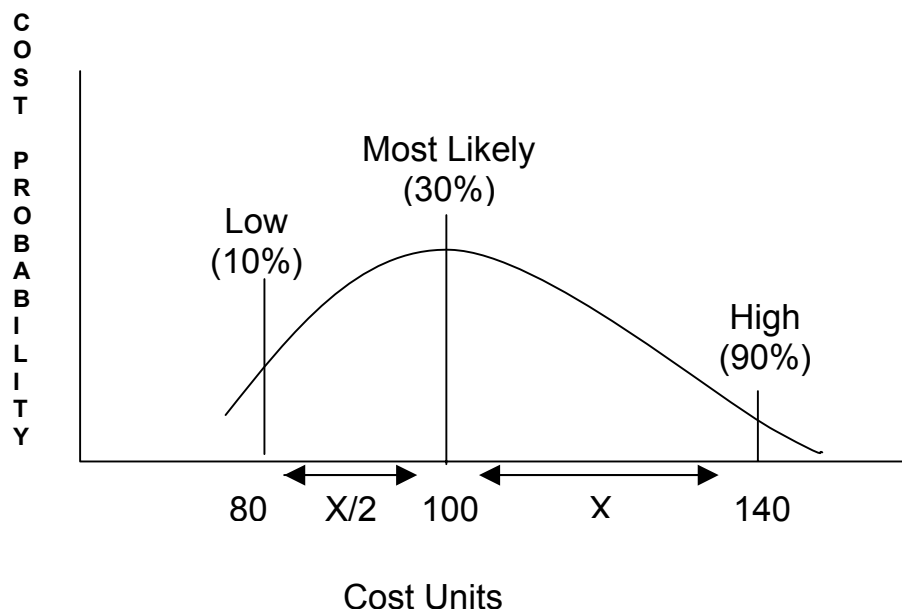
80    X/2    100        X        140

Cost Units

Figure 2: Distribution of estimated human factors costs

Note: This figure shows several estimated human factors cost relationships, including:

1. Confidence Levels for Cost Estimates:
- High level of confidence = 90% of the cost risk is identified by the cost estimate
- Low level of confidence = 10% of the cost risk is identified by the cost estimate
- Most Likely = Best estimate of the cost

2. Confidence Level Differences: The difference between the High confidence levels and Most Likely is twice the distance between Most Likely and Low confidence levels.

3. Confidence Level Values: High confidence estimates are 140% of Most Likely estimates; and Low confidence estimates are 20% below Most Likely estimates.

**Table 2.1: Program Attributes Affecting Human Factors Costs**

| Program Attributes (Weight: % of HF Cost) | | Attribute Descriptors and Cost Values (As a percentage of program developmental cost) | | | | |
|---|---|---|---|---|---|---|
| Definition or Agreement on Human-System Interface Requirements | Descriptors | Highly Defined and Resolved | Largely Defined and Resolved | Moderately Defined or Resolved | Somewhat Undefined or Unresolved | Highly Undefined or Unresolved |
| (25%) | Cost % | 0.13 | 0.37 | 0.75 | 1.0 | 1.5 |
| Human-System Integration Complexity | Descriptors | Very Low | Low | Moderate | High | Very High |
| (20%) | Cost % | 0.1 | 0.3 | 0.6 | 0.8 | 1.2 |
| Organizational Culture, Stakeholder Interests | Descriptors | Very Conducive | Conducive | Moderate | Resistant | Very Resistant |
| (20%) | Cost % | 0.1 | 0.3 | 0.6 | 0.8 | 1.2 |
| Program Pace | Descriptors | Very Slow | Slow | Moderately Paced | Aggressive | Very Aggressive |
| (15%) | Cost % | 0.07 | 0.23 | 0.45 | 0.6 | 0.9 |
| Safety Considerations | Descriptors | Very Low | Somewhat Low | Moderate | Somewhat High | Very High |
| (10%) | Cost % | 0.05 | 0.15 | 0.3 | 0.4 | 0.6 |
| External/ International Collaboration Needs | Descriptors | Very Low | Low | Moderate | High | Very High |
| (10%) | Cost % | 0.05 | 0.15 | 0.3 | 0.4 | 0.6 |
| **TOTAL** | | **.5%** | **1.5%** | **3%** | **4%** | **6%** |

# Attachment 3
# Types of Human Factors Costs

In estimating human factors costs, one should include the various sources of personnel, material, and incidental costs.  These cost sources include both Government costs (federal and contractor support) and vendor/developmental contractor costs.  Costs may be incurred during any of the phases of the system lifecycle and estimates should include (but not be limited to) those associated with two general categories of activities (adapted from Mantei and Teorey, 1988):

| Development Activities | Usability Activities |
| --- | --- |
| Feasibility study and analysis | Market analysis |
| User/target audience description | Cost/benefit/risk analysis |
| Requirements definition | Product acceptance analysis |
| Design and analysis | Task analysis |
| Prototype construction | User testing and evaluation |
| System implementation | Product survey |
| Product testing | Post-implementation assessment |
| Design update and maintenance | |

For the purposes of this document, the following types of costs may be considered to fall under human factors program management costs when addressing human performance or human-system interface issues:
1.  Design engineering and analysis cost
2.  Software personnel programming cost
3.  Human factors staff cost
4.  Laboratory/facility cost
5.  Study participant cost
6.  Subject matter expert cost
7.  User needs assessment cost
8.  Concept studies cost
9.  Prototype and usability assessment costs
10. Modeling and fast-time simulations cost
11. Human-in-the-loop simulation cost
12. Experiment/study plan development cost
13. Scenario development cost
14. Scenario shakedown cost
15. Final simulation cost
16. Data collection cost
17. Data analysis cost
18. Final report development cost
19. Coordination, communication, and implementation costs

[Note: If a study, experiment, test, or other activity involves human performance assessment, human-system interface design, or human performance data collection or analysis, costs associated with human factors tasks should be considered as part of human factors cost. For example, if human factors personnel participate in maintainability testing to gather maintainer performance data, the cost of this participation is allocated to human factors, but not the total cost of the maintainability testing."]

# Attachment 4
# Human Factors Cost Distribution

Human factors costs may need to be estimated for the various phases of a program or for various activities within a phase. The two tables below provide a (notional) relative distribution of human factors costs:

**1. For Acquisition Phases:** Using the FAA Acquisition Lifecycle Management Policy phases, the human factors costs are parsed across phases. The relative human factors cost distribution may be adjusted as appropriate for the particular acquisition, the program's specific human factors risk, and the mitigation strategies selected. These costs are then to be integrated with other program cost estimates to support the Acquisition Program Baseline and program planning.

**Table 4.1 Human Factors Costs by Acquisition Phase/WBS Level 1**

| Program Cost Category | Relative Human Factors Cost Distribution |
|---|---|
| Mission Analysis | 10 |
| Investment Analysis | 15 |
| Solution Development and Implementation | 60 |
| In-service Management | 10 |
| Disposition and Service Life Extension | 5 |
| TOTAL | 100% |

**2. For Work Breakdown Structure (WBS) Level 2:** Using the FAA Work Breakdown Structure (especially element 3.0, Solution Development) the human factors costs are parsed into the program element cost categories below. The relative human factors cost distribution may be adjusted as appropriate for the particular acquisition, the program's specific human factors risk, and the mitigation strategies selected. These costs are then to be integrated with other program cost estimates to support the Acquisition Program Baseline and program planning.

**Table 4.2 Human Factors Costs by WBS Solution Development Category**

| Program Cost Category | Relative Human Factors Cost Distribution |
|---|---|
| 3.1 Program Management | 10% |
| 3.2 System Engineering | 15% |
| 3.3 HW/SW Design, Development, Procurement, and Production | 50% |
| 3.4 Facilities and Physical Infrastructure Design and Development | 5% |
| 3.5 Test and Evaluation | 10% |
| 3.6 Documentation | 5% |
| 3.7 Logistics Support | 5% |
| TOTAL | 100% |

**Attachment 5**
**Summarized Steps for Human Factors Assessments in Investment Analysis**

**STEP 1: Conduct Benefits Analysis to Determine:**
    a) Human-in-the-loop system performance limitations
    b) Human-in-the-loop system performance enhancements

**STEP 2: Conduct Risk Analysis to Determine the:**
    a) Human factors risks
    b) Probability/severity ratings for human factors risks
    c) Human factors mitigation strategies/activities

**STEP 3: Conduct Cost Analysis to:**
    a) Estimate human factors mitigation costs
    b) Estimate costs associated with human factors benefits/enhancements
    c) Aggregate human factors mitigation and enhancement costs
    d) Calculate risk-based human factors costs at 80 or 90% level
    e) Distribute 80 or 90% risk-based human factors cost among WBS elements

**STEP 4: Integrate the Results with Other Investment Analysis and Program Products**